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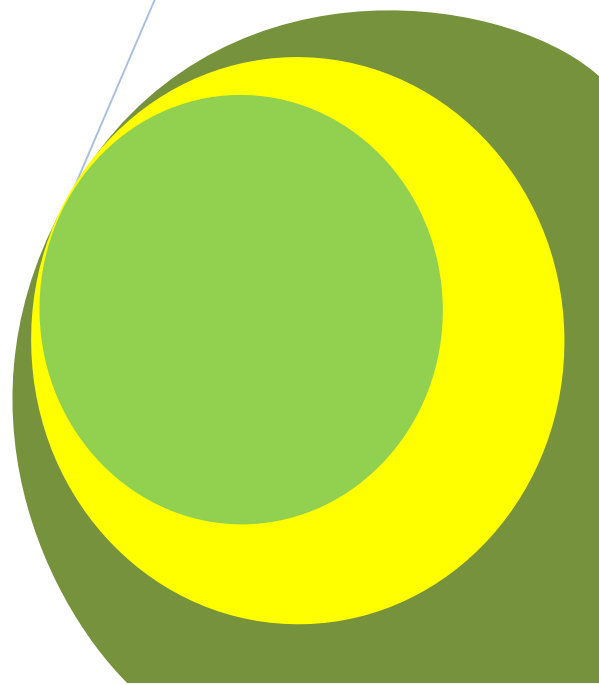
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Research Article

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ABSTRACT

African fish eagles (*Haliaeetus vocifer*) are important birds of prey and indicator of ecosystem integrity in aquatic environments. We assessed the population abundance and spatial distribution of African fish eagles along three major rivers in Gonarezhou National Park, Zimbabwe. Data were collected using walked transect surveys along Mwenezi, Runde and Save rivers in Gonarezhou between March and April 2011. A total of 54 African fish eagles were recorded with an average density of 0.62 individuals per km. African fish eagles were mostly distributed in areas with large water pools along Gonarezhou's three major rivers. The results suggest that large pools along perennial rivers are important in the distribution and density of African fish eagles in Gonarezhou. Future studies should aim at establishing the long-term population trends of birds of prey in Gonarezhou.

Keywords: African fish eagle, population, savanna, riparian vegetation, perennial river.

INTRODUCTION

Birds of prey are reliable indicators of terrestrial biodiversity and environmental health status of landscapes (Ormerod and Tyler, 1993; Bibby, 1999; Gregory and van Strien, 2010). The African fish eagle (*Haliaeetus vocifer*) is distinctive in appearance with a mostly brown body and large, powerful and black wings (Unwin, 2011). With its distinctive plumage and cry, the clear, ringing call of the African fish eagle is the most characteristic and evocative sound of African watersides (Ferguson-Lees and Christie, 2001). As their name implies, African fish eagles of suborder *Accipitres*, and family of *Accipitridae*, are indigenous to sub-Saharan Africa, ranging over most of the water resources (Hollamby et al., 2004).

The African fish eagle is classified as Least Concern on the International Union for Conservation of Nature and Natural Resources Red List of Threatened species (IUCN, 2012). According to the optimal foraging theory, birds of prey's foraging distribution is predicted to be nonrandom, i.e., most hunting or search for prey and distributional presence occur in habitat patches yielding the greatest net energy gain (Pyke, 1984). Hence, most African fish eagles are more likely to be distributed in areas offering the highest density of prey. African fish eagles are a species of aquatic ecotone habitat, with live fish accounting for the bulk of its diet (Chandler et al., 1995). However, non-fish prey has also been reported as forming a considerable proportion of African fish eagle diet probably representing both opportunistic hunting, especially when conditions for fishing are poor, and also the killing of other predators robbing African fish eagle nests (Stewart et al., 1997).

Current abundances, distribution, and population trends of African fish eagle in Gonarezhou National Park (hereafter, Gonarezhou), Zimbabwe are poorly known, preventing an assessment of the current conservation status of the species in Gonarezhou (ZPWMA, 2011). Knowledge of African fish eagles' spatial distribution and population abundance in protected areas is useful in guiding restoration and management of natural habitats. Therefore, the objectives of this study were twofold: 1) to establish the current abundance of

African fish eagles, and 2) to determine the current spatial distribution of African fish eagles along the three major rivers draining Gonarezhou, namely; Mwenezi, Runde and Save.

MATERIALS AND METHODS

Study area

Gonarezhou covers approximately 5,050 km² and is the second largest state protected area in Zimbabwe. The national park is located in southeastern Zimbabwe, between latitudes 21° 00' - 22° 15' S and longitudes 30° 15' - 32° 30' E. Gonarezhou is part of the Great Limpopo Transfrontier Park including Limpopo National Park in Mozambique and Kruger National Park in South Africa. The major vegetation type is typical of semi-arid *Colophospermum mopane* woodland and is predominantly dry deciduous savanna woodland of varying types. Long-term mean annual rainfall for Gonarezhou is 466 mm with most of the rain falling between November and April. Gonarezhou is endowed with three major perennial rivers, namely Mwenezi, Runde and Save (Fig. 1) and numerous water pans. The flow pattern in all the three major rivers has been disturbed by upstream activities, vegetation degradation, dams and irrigation. The water pans in the Gonarezhou are quite extensive and these temporarily hold water for some time especially after precipitation.

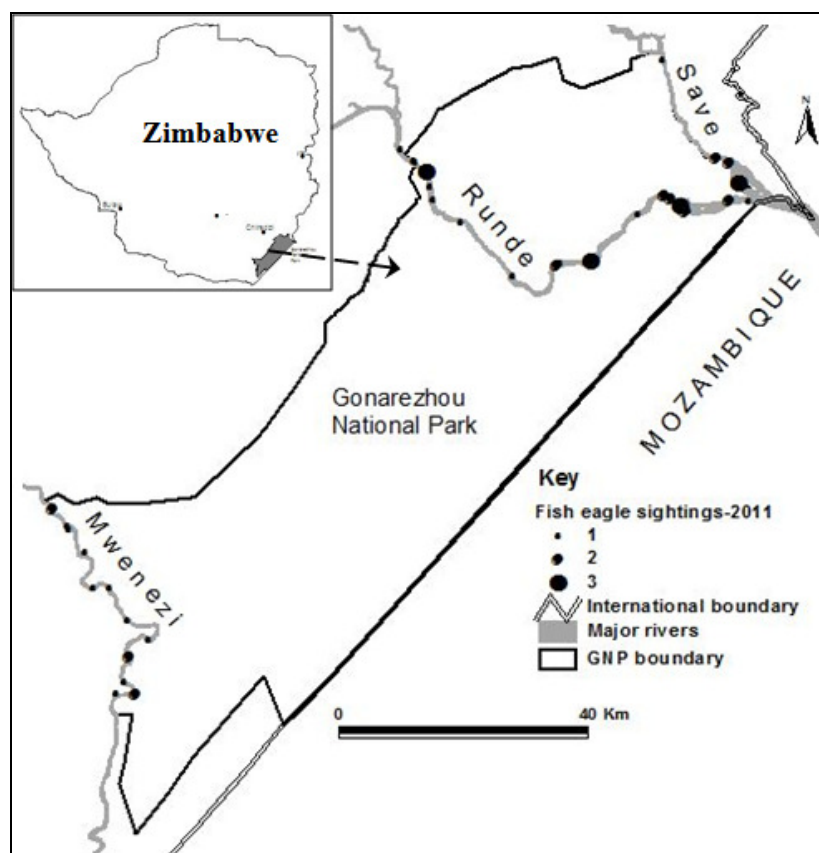


Figure1: Location of the three major perennial rivers (Mwenezi, Runde and Save) and spatial distribution of African fish eagles in Gonarezhou National Park, Zimbabwe.

Study design and sampling procedure

We used a stratified random sampling design technique with survey line transects being randomly selected (Dawson, 1985). Line transects are the preferred survey method, commonly used in bird surveying to derive relative and absolute measures of bird abundance and distribution (Buckland et al., 1993). African fish eagles are commonly found along banks of major rivers and thus, can be easily detected when perched to hunt fish (Steyn, 1885). The study area was divided into three strata namely; Mwenezi River (57 km), Save River (32 km) and Runde River (77 km). Line transects of equal length, i.e. ~4 km, were delineated in each stratum for easy coverage in the riparian zones (Bibby et al., 2000). A total of 41 line transects were delineated within the study

area, using Gonarezhou topographic map, and out of these a total of 21 line transects were randomly selected using random number tables and sampled across the three strata (Table 1). The number of line transects sampled in each study stratum was proportional to the total length of a particular stratum, so as to maintain a relatively uniform sampling intensity.

Table 1: Transects delineated and sampled for abundance and distribution of African fish eagles in Gonarezhou National Park, Zimbabwe.

Study stratum	Transects length (km)	Line transects delineated	Line transects sampled	Sampled transect lengths (km)
Mwenezi River	57	14	7	28
Runde River	77	19	10	40
Save River	32	8	4	16
Total	166	41	21	84

Ground surveys for African fish eagles were carried out between March and April 2011. This period coincided with the African fish eagles' breeding season in Zimbabwe. Direct observation methods of transect counts were used in data collection (Bibby et al., 2000). All African fish eagles seen perched or flying along the selected line transects were counted by two people (one observer and one recorder) while walking downstream (at $\sim 3 \text{ km}^{-1}$) in open areas along the river banks from after sunrise to before sunset (7:00–18:00 hrs) with the aid of 10×42 binoculars. In this study, we didn't measure the distance from the observer to the sighted bird(s). A Global Positioning System (GPS) unit was used to record co-ordinates of a particular point corresponding to sighting of the African fish eagles and any encountered nest. Moreover, we did not collect detailed information on the nests themselves, i.e., tree species where the nests were, height of the nest on the tree and also structure of the trees.

Data analysis

Descriptive statistics were used to summarise the African fish eagles' population and nest abundances data. Moreover, densities of African fish eagles' population and nest abundances per river km were calculated. A Chi-square (χ^2) goodness-of-fit test was used to determine if there were differences in the abundances of African fish eagles among the three major rivers in Gonarezhou. For spatial distribution across Gonarezhou, location points of African fish eagles sightings recorded using a GPS unit were entered into a Geographical Information System (GIS) environment using Arc-View 3.2 for Windows to produce African fish eagle's distribution patterns along the three major perennial rivers. This then reflected the spatial distribution pattern of African fish eagles in Gonarezhou for the year 2011.

RESULTS

Abundance of African fish eagles

The line transect surveys recorded a total of 54 African fish eagles (Table 2) with an average density of 0.62 individuals per km along the three perennial major rivers in Gonarezhou. The percentage contributions of African fish eagles' abundance varied across the three study strata with Runde River having the greatest contribution of 56%, Mwenezi River contributed 27%, and the least contribution being Save River study stratum with 17% ($\chi^2 = 13.00$, $df = 2$, $P = 0.002$). The abundance of African fish eagle nests was also greater along Runde River followed by Mwenezi River and then Save River.

Table 2: Summary results from sightings of African fish eagles and nests along the three major perennial rivers in Gonarezhou National Park, Zimbabwe.

River	African fish eagle sightings	Density of African fish eagles (per km)	Active nests	Density of active nests (per km)	Non-active nests	Density of non-active nests (per km)
Mwenezi	15	0.54	0	0.00	3	0.11
Runde	30	0.75	2	0.05	5	0.13
Save	9	0.56	0	0.00	2	0.13
Total	54	1.85	2	0.05	10	0.36
Mean	18	0.62	0.67	0.02	3.33	0.12
Standard error	6.24	0.07	0.67	0.02	0.88	0.01

Spatial distribution of African fish eagles

The spatial distribution of African fish eagles along the three major perennial rivers in Gonarezhou had varying patterns, with uneven distribution along Save River stratum; where much of the river stretch recorded no sighting of African fish eagles, except only the area forming the Save-Runde River confluence (Fig. 1). As for Runde River, there was a high population density of African fish eagles' within the Chipinda Pools area and towards the Save-Runde River confluence, while notable sightings of African fish eagles were recorded on the Chilolo Cliffs area. Along the Mwenezi River stratum, African fish eagle's distribution was evenly spaced throughout the stratum (Fig. 1), with notable high African fish eagle sightings at Lipakwa Pool and Rossi Pool.

DISCUSSION

The study showed evidence of high sightings and distribution of African fish eagles in close proximity to large water pools along the three major perennial rivers, in particular, Chipinda Pools, Chilolo Cliff Pools along Runde River, Lipakwa Pool, Rossi Pool along Mwenezi River and Save-Runde River confluence in Gonarezhou. Aquatic habitat characteristics such as river flow patterns and water depth are likely to influence the availability of fish for the preying African fish eagles in Gonarezhou. Similarly, African fish eagle's nests were more abundant at large water pools, suggesting that most fish populations were present in these sites, hence, prey availability and also availability of large trees may have contributed to the abundance and distribution of African fish eagles in these sites. Accordingly, some predator prey models assume a direct relationship between foraging distribution and prey density (MacArthur and MacArthur, 1961) and this could explain the noticeable high sightings of African fish eagles and nests in close proximity to large water pools along the three major perennial rivers in Gonarezhou.

The current abundance of African fish eagles across the three Gonarezhou major rivers, however, may also be the result of changes in river catchments as shown by reduced water flow across the catchments of the three study strata of Gonarezhou as evidenced by siltation and disappearance of large pools (e.g., O'Connor and Campbell, 1986; Zisadza et al., 2010; Zisadza-Gandiwa et al., 2013a). For instance, upstream damming, erosion, siltation, deforestation, herbivory, fire, poaching and pollution may all influence water flow and quality in the main rivers traversing Gonarezhou and also populations of birds of prey (ZPWMA, 2011; Gandiwa et al., 2012). Moreover, recent incidences of poisoning birds of prey is of major concern in Gonarezhou (Groom et al., 2013), especially when considering the African fish eagle abundances.

Habitat degradation has been suggested as a likely cause for low population density of African fish eagles (Eltringham, 1975; Anadón et al., 2010; Virani et al., 2011). The African fish eagle nests and perches in large trees and forages for fish along lakes, rivers and coastline is affected by both terrestrial and aquatic habitat degradation (Meyburg and Chancellor, 1994; Hollamby et al., 2006). Thus, habitat degradation could reduce the availability of trees for nesting and perching while erosion-induced siltation likely reduces prey abundance and availability. Along Save River, the low frequency sighting of African fish eagles could be attributed to anthropogenic influences. Persecution by humans through harvesting of potential nest and perch trees, shooting, trapping, and destruction of nests and young birds is another threat to African fish eagles, even where suitable habitat remains (Meyburg and Chancellor, 1994).

Earlier studies have provided some valuable information on factors influencing the abundance and distribution of African fish eagles in the savannas. For example, Douthwaite (1992) studying the effects of water pollutants in the African fish eagle's population of Lake Kariba, Zimbabwe, suggested that the population was limited more by the availability of suitable nesting trees than mercury or organic chlorine pollutants. Elsewhere, Harper et al. (2002), in a 13-year study of the African fish eagle population in Lake Naivasha, Kenya, showed that the population was limited by lack of available prey associated with eutrophication, perching tree availability and other factors linked to anthropogenic habitat alteration. In contrast, Mundy and Couto (2000) suggested that eutrophication may have played a role in high productivity by African fish eagles on the polluted Lake Chivero, Zimbabwe. Interestingly, the recorded density of African fish eagles in Gonarezhou is within the previously reported density range for river ecosystems (e.g., Krueger, 1997; Harper et al., 2002).

Additionally, elevated threats of poaching, hunting and persecution in the unprotected areas upstream may have induced some African fish eagles to migrate downstream into the Gonarezhou. This is because about 77 km of the Runde River and 57 km of Mwenezi River is contained inside the protected area of the Gonarezhou where law enforcement for resource protection is relatively effective compared to the adjacent communal areas (*E. Gandiwa, personal observation*). This may explain the higher sighting frequency of African fish eagles within Runde River and Mwenezi River strata, and also the high density of African fish eagles at the Save-Runde confluence area. Outside protected areas, African fish eagles are more vulnerable due to anthropogenic effects (Thiollay, 2007), as also recorded for some sections the Save River which shares a boundary with communal areas where there were no sightings of African fish eagles and nests.

We recorded a total of 54 African fish eagles and also a variable distribution of African fish eagles along the three major perennial rivers in Gonarezhou. Our results suggest that the African fish eagles in Gonarezhou are likely influenced by river flow regimes which have a bearing on prey availability. We surprisingly recorded a low number of active nests for the African fish eagles despite the fact that our study was conducted during the

breeding season for the study species. Thus, it is likely that we may have missed some of the African fish eagles' nests, particularly the active nests, along the study rivers since our belt transects width were relatively small, i.e. only focusses on areas adjacent to the riverbanks. Furthermore, previous research in Gonarezhou has reported that vegetation close to rivers is generally negatively affected by elephant herbivory, hence reducing the densities of large trees along the study rivers (Tafangenyasha, 1997; Zisadza-Gandiwa et al., 2013b), and consequently leading to reduced nesting sites. Similarly, it is likely that past tsetse control clearing activities led to the removal of large trees along some section of the study rivers (Gandiwa and Kativu, 2009), thus affecting the present day nesting sites for the fish eagles. Given the level of present day human influence, Runde and Mwenezi rivers are less affected than Save River which borders the local communities, thus we infer that Runde and Mwenezi rivers have a healthier riparian system than Save River which borders local communal areas.

Interestingly, the present study results also revealed that Save-Runde River confluence, an Important Bird Area occurring inside Gonarezhou (Gandiwa et al., 2013) had the highest population abundance of African fish eagles. The present study presents a snapshot of the current status of African fish eagle's abundance and distribution and this could be used as a temporal reference point for future research and also management decisions on the species. As top predators, African fish eagles have large area requirements, therefore, identifying and protecting suitable African fish eagles habitat and monitoring their population and spatial distribution patterns will benefit a host of other species that depend on wetland habitats in Gonarezhou and other protected areas, thus enhancing biodiversity conservation efforts and avian management. Therefore, future research should aim at establishing the following: (i) abundance and distribution of African fish eagles in areas with permanent and seasonal water points; (ii) long-term population trends of birds of prey in Gonarezhou, and associated competition among the birds of prey (e.g., Krueger, 1997) in savanna ecosystems; (iii) seasonal variation in African fish eagles numbers along rivers; (iv) variation among African fish eagles numbers along rivers inside and areas bordering the protected area; and (v) fish populations and large trees for perching in the different rivers and habitats in order to determine the relationship with abundances of African fish eagle numbers.

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